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Predicted Weights and Volumes of Northern Red Oak Trees in Western North Carolina

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Conversion factors: English to metric

Multiply	*by*	*To obtain*
Inches	2.540	centimeters
Feet	.3048	meters
Pounds	.4536	kilograms
Cubic feet	.02832	cubic meters
Pounds per cubic feet	16.02	kilograms per cubic meter

All English units of measure in this report can be converted to metric units by multiplying by the appropriate conversion factor listed above.

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Predicted Weights and Volumes of Northern Red Oak Trees in Western North Carolina[1]

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ABSTRACT.—Total weights and volumes, above stump, were determined for 71 northern red oak (*Quercus rubra* L.) trees 6 to 24 inches d.b.h. growing in fully stocked oak-hickory stands in western North Carolina. Equations are presented for predicting green and dry weights and green volume of the total tree, above stump, and its components using d.b.h. and total height, d.b.h. and height to a 4-inch top, d.b.h. and saw-log merchantable height, and d.b.h. alone. Tables developed from equations show weight and volume of the total tree and its components by d.b.h. and total height classes. Seventy-five percent of total-tree weight was in stem to a 4-inch top and 25 percent in crown. The average tree had 85 percent of its green weight in wood and 15 percent in bark. Total-tree wood had an average specific gravity of 0.581, an average moisture content of 80 percent, and an average green weight per cubic foot of 65 pounds. The average weight of wood and bark per cubic foot of wood for the total tree was 77 pounds.

Keywords: *Quercus rubra* L., biomass, component proportions, equations, specific gravity, moisture content, weight per cubic foot.

Increasing demands for wood, escalating costs, and the energy shortage have forced forest industries in the South to consider utilizing all parts of trees. Utilizing the total tree above the stump compared to utilizing only the merchantable stem can increase yields from individual hardwood trees by as much as 65 percent (Clark 1978). Equations for estimating total-tree weight and volume are needed to evaluate and utilize total trees.

This Paper presents green volumes and green and dry weights of above-stump biomass of commercial-size northern red oaks (*Quercus rubra* L.) growing in uneven-aged stands in the mountains of western North Carolina. Equations and yield tables predict weight and volume of the total tree and its components (wood, bark, saw logs, stem, and crown). Wood and bark specific gravity, moisture content, and green weight per cubic foot are presented for the total tree and its components.

PROCEDURES

Field

A total of 71 northern red oak trees were selected from two fully stocked, uneven-aged oak-hickory stands to determine winter biomass. A stratified random sample of 36 pulpwood-size trees (trees 5.6 to 11.5 inches d.b.h.) was selected from a stand in Haywood County on the French Broad District of the Pisgah National Forest. The dominant and codominant trees in the stand were 10 to 14 inches d.b.h., and the stand had an average site index for northern red oak of 80. Five

[1]This study was conducted in cooperation with the Range, Timber, and Wildlife Program Area of Region 8 of the National Forest System. Field personnel were provided by the Pisgah and French Broad Ranger Districts of the Pisgah National Forest.

to seven trees were selected from each 1-inch d.b.h. class from 6 to 11 inches d.b.h. The trees sampled ranged from 41 to 55 years old and averaged 49 years.

A second stratified random sample of 35 dominant and codominant sawtimber-size trees (≥ 11.6 inches d.b.h.) was selected from a mature stand in Buncombe County on the Pisgah District of the Pisgah National Forest. The stand had an average site index of 90. Three to six trees from each 2-inch d.b.h. class were sampled. Form class of the sawtimber trees ranged from 71 to 86 and averaged 79. The trees ranged from 53 to 114 years old and averaged 76 years. Means and ranges in dimensions of sample trees are shown in table 1.

Trees were felled and limbed during the winter, and the main stem of each tree was bucked into merchantable saw logs and pulpwood. Saw logs 8 to 16 feet long were cut from the main stem to an 8-inch d.i.b. top or to a degrading quality indicator such as large knots. Stem d.i.b. at the saw-log top averaged 9.9 inches (table 1). All material between the saw-log merchantable top and the 4-inch d.i.b. top was classed as "pulpwood." All trees had a discernible main stem to a 4-inch top. In pulpwood trees, stem material between the 4- and 2-inch d.i.b. tops was classed as "topwood." The crown of sawtimber-size trees was cut up and weighed in two categories: (1) branches ≥ 4.0 inches d.o.b., and (2) branches < 4.0 inches d.o.b. Pulpwood crowns were divided into branches ≥ 2.0 inches and branches < 2.0 inches d.o.b. The tip of the stem (2 inches d.i.b. to top) was included as branch material in the study. All crown and pulpwood material was weighed to the nearest one-quarter pound. Saw logs were weighed individually to the nearest pound.

From each sawtimber tree, disks were removed at the butt, at each saw-log bucking point, at the points where d.i.b. measured 8, 6, and 4 inches, and from branches randomly selected from each branch-size category. In pulpwood-size trees, disks were cut at the butt, at quarter points to a 4-inch top, and at a 2-inch top. Each disk was sealed in a polyethylene bag for subsequent determinations of moisture content, specific gravity, and bark percent.

Laboratory

Specific gravity was computed on a green-volume and ovendry-weight basis. Moisture con-

Table 1.—Means and ranges in dimensions of northern red oak trees sampled on the Pisgah National Forest in western North Carolina

D.b.h. class (inches)	Sample trees	D.b.h.		Total height		Height to 4-inch d.i.b. top		Height to saw-log merchantable top[1]		D.i.b. at saw-log merchantable top	
		Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
	Number	..... *Inches*		..... *Feet*						..... *Inches*	
6	5	6.1	5.9– 6.4	61	56– 64	28	18–33	—	—	—	—
7	7	7.1	6.6– 7.5	66	53– 72	39	33–43	—	—	—	—
8	7	8.1	7.6– 8.5	69	66– 74	42	36–48	—	—	—	—
9	5	9.0	8.7– 9.4	75	74– 77	48	43–51	—	—	—	—
10	6	10.1	9.6–10.5	76	65– 82	52	44–65	—	—	—	—
11	6	11.0	10.6–11.3	80	72– 86	58	55–60	—	—	—	—
12	5	12.2	11.7–12.9	83	67–104	60	50–79	33	25–37	9.1	8.2– 9.8
14	5	14.3	13.9–14.9	94	91– 98	70	65–75	47	35–64	8.3	7.4– 9.9
16	6	15.6	15.0–16.1	96	82–107	73	61–84	48	37–65	9.4	8.2–11.8
18	6	17.7	17.0–18.5	98	89–103	77	70–84	54	43–62	10.0	7.6–12.6
20	5	20.1	19.0–20.9	102	96–106	79	72–87	53	45–62	10.8	9.4–12.5
22	5	22.0	21.3–22.7	106	98–118	88	82–93	62	50–78	9.3	7.8–13.1
24	3	24.0	23.6–24.7	102	91–116	84	76–98	53	50–60	14.7	14.3–15.0
All classes	71	13.0	5.9–24.7	84	53–118	60	18–98	50	25–78	9.9	7.4–15.0

[1]Height to 8-inch d.i.b. or saw-log merchantable top.

tent was computed on an ovendry-weight basis after samples were dried to a constant weight at 103° C. Percentage of bark was determined from disks on a green-weight basis. Moisture content, specific gravity, and percentage of bark in stem, branches, and total tree were calculated by weighting disk values in proportion to the volume of the component they represented. Weighted values for moisture content were used to convert component green weights to ovendry weights.

Green weights per cubic foot of wood and bark were calculated from weighted values for specific gravity and moisture content with the equation:

$$\text{Green weight per cubic foot} = \left[1 + \frac{M.C.}{100}\right] \times (S.G.) \times (C) \quad (1)$$

where:

M.C. = weighted moisture content in percent,
S.G. = weighted specific gravity,
C = 62.4 pounds (weight of water per cubic foot).

Cubic-foot volume of green wood and bark were computed by dividing component weight by its green weight per cubic foot. Total green cubic-foot volume (wood and bark combined) was computed by adding the green volume of bark to the green volume of wood.

Analysis

Linear regression equations were developed to predict green and dry weights and green volumes of wood and bark in the total tree and its components. Independent variables were: diameter at breast height (D), total height (Th), sawlog merchantable height (Mh), and height to a 4-inch top (H4), both separately and in various combinations.

Grouping the data into D^2Th classes and plotting the variance of Y over D^2 and D^2Th indicated that the variances of predicted weights and volumes increased with increasing D^2 and D^2Th. A logarithmic transformation (to the base 10) was used to obtain a relatively homogeneous variance, which is assumed in regression analysis. Thus, regression equations for tree and component weights and volumes were calculated using the equations:

$$\log Y = b_0 + b_1 \log X + \epsilon \quad (2)$$

$$\log Y = b_0 + b_1 \log X_1 + b_2 \log X_2 + \epsilon \quad (3)$$

where:

Y = predicted weight or volume of component
X = D^2, D^2Th, D^2H4, or D^2Mh,
X_1 = D^2,
X_2 = Th, H4, or Mh
ϵ = sampling error,
b_i = regression coefficients.

When logarithmic estimates are converted back to original units, they are biased downward because the antilogarithm of an estimated mean gives the geometric rather than the arithmetic mean (Cunia 1964). To account for this bias, a correction factor was computed using a procedure described by Baskerville (1972) and applied to each equation. The equation forms, including the correction factor, are:

$$Y = 10^{b_0 + b_1 \log X + \frac{S^2_{y \cdot x}}{2}} \quad (4)$$

and

$$Y = 10^{b_0 + b_1 \log X_1 + b_2 \log X_2 + \frac{S^2_{y \cdot x}}{2}} \quad (5)$$

where:

$S^2_{y \cdot x}$ = error mean square from regression analysis

Equations (4) and (5) can be simplified to:

$$Y = aX^{b_1} \quad (6)$$

and

$$Y = aX_1^{b_1} X_2^{b_2} \quad (7)$$

where:

$$a = 10^{b_0 + \frac{S^2_{y \cdot x}}{2}}$$

Separate prediction equations were developed for the pulpwood and sawtimber trees. Statistical tests (Snedecor and Cochran 1967) indicated no significant differences in the slopes or intercepts of these equations at the 0.01 probability level for the total tree and stem weights or volumes. Therefore, the pulpwood and sawtimber trees were combined, and one series of equations was developed for trees 6 to 24 inches d.b.h.

SAMPLE TREE CHARACTERISTICS

Total Tree

Green weight of the trees sampled ranged from an average of 457 pounds for 6-inch trees to 12,535 pounds for 24-inch trees. Assuming the trees were composed solely of wood, bark, and water, 44 percent of their green weight was water; 47 percent was wood; and 9 percent was bark. The proportions of total-tree weight in wood and bark did not vary with tree size. The proportion of tree weight in bark ranged from 14 to 17 percent and averaged 15 percent on a green basis. On a dry basis, bark made up an average of 17 percent of total-tree weight.

The proportion of tree weight in crown material (all live branches and stem < 4-inch d.i.b.) ranged from 19 to 29 percent on a green basis but did not vary consistently with tree size. The proportion of tree green weight in crown averaged 25 percent, and the proportion in the stem to a 4-inch top averaged 75 percent.

The green and dry weights of all wood and bark and the distribution of wood and bark throughout the tree are presented in tables 2 and 3 for pulpwood trees and in tables 4 and 5 for sawtimber trees. On the average, pulpwood trees had 79 percent of their total green wood weight in the stem to a 4-inch d.i.b. top and 21 percent in the crown (topwood and branches). Sawtimber trees on the average had 77 percent of their green wood weight in the stem to a 4-inch top and 23 percent in crown. Sixty-six percent of their green wood weight was in saw-log material and 11 percent in pulpwood. Wood and bark were not distributed evenly throughout the tree; the stem to a 4-inch top of the average sawtimber tree contained 77 percent of all the green wood in the tree but only 61 percent of the bark. Sawtimber tree crowns contained 23 percent of the green wood and 39 percent of the bark.

Stem Components

The proportion of stem weight to a 4-inch top in wood increased and the proportion in bark decreased as stem d.b.h. increased. The proportion of stem weight in wood increased from 85 percent

Table 2.—Average green and dry weights of wood in the total tree and distribution of wood in main stem and branches in northern red oak pulpwood trees

D.b.h. class (inches)	Average total height	Sample trees	Total-tree wood weight	Proportion of wood in —					
				Main stem			Branches (inches d.o.b.)		
				Pulpwood[1]	Topwood[2]	Total stem[3]	≥ 2 inches	<2 inches	All branches
	Feet	*Number*	*Pounds*	*Percent*					
				GREEN					
6	61	5	381	73	11	84	4	12	16
7	66	7	547	77	9	86	3	11	14
8	69	7	766	78	6	84	6	10	16
9	75	5	999	77	5	82	8	10	18
10	76	6	1,288	79	3	82	8	10	18
11	80	6	1,566	83	2	85	6	9	15
Average	—	—	923	79	5	84	6	10	16
				DRY					
6	61	5	215	72	12	84	3	13	16
7	66	7	311	76	9	85	3	12	15
8	69	7	426	76	7	83	6	11	17
9	75	5	560	76	6	82	7	11	18
10	76	6	718	78	3	81	8	11	19
11	80	6	868	81	3	84	6	10	16
Average	—	—	517	78	5	83	6	11	17

[1]Pulpwood in stem from butt to 4-inch d.i.b. top.
[2]Stem material from 4-inch to 2-inch d.i.b. top.
[3]Main stem to 2-inch d.i.b. top.

Table 3.—Average green and dry weights of bark in the total tree and distribution of bark in main stem and branches in northern red oak pulpwood trees

D.b.h. class (inches)	Average total height	Sample trees	Total-tree bark weight	Proportion of bark in —					
				Main stem			Branches (inches d.o.b.)		
				Pulp-wood[1]	Top-wood[2]	Total stem[3]	≥ 2 inches	< 2 inches	All crown
	Feet	*Number*	*Pounds*	..... *Percent*					
				GREEN					
6	61	5	76	60	13	73	5	22	27
7	66	7	104	65	10	75	4	21	25
8	69	7	146	66	7	73	7	20	28
9	75	5	185	65	5	70	10	20	30
10	76	6	229	67	2	69	10	21	31
11	80	6	266	70	2	72	8	20	28
Average	—	—	167	66	6	72	8	20	28
				DRY					
6	61	5	46	60	13	74	5	21	26
7	66	7	63	65	10	75	4	21	25
8	69	7	90	67	7	74	8	18	26
9	75	5	109	66	5	71	10	19	29
10	76	6	139	67	3	70	10	20	30
11	80	6	160	71	2	73	8	19	27
Average	—	—	101	67	6	73	8	19	27

[1]Pulpwood in stem from butt to 4-inch d.i.b. top.
[2]Stem material from 4-inch to 2-inch d.i.b. top.
[3]Main stem to 2-inch d.i.b. top.

Table 4.—Average green and dry weights of wood in the total tree and distribution of wood in main stem and branches in northern red oak sawtimber trees

D.b.h. class (inches)	Average total height	Sample trees	Total-tree wood weight	Proportion of wood in —					
				Main stem			Branches (inches d.o.b.)		
				Saw-log[1]	Pulp-wood[2]	Total stem[3]	≥ 4 inches	< 4 inches	All branches
	Feet	*Number*	*Pounds*	..... *Percent*					
				GREEN					
12	83	5	2,139	56	23	79	4	17	21
14	94	5	3,346	65	12	77	9	14	23
16	96	6	3,957	65	13	78	10	12	22
18	98	6	5,169	69	10	79	11	10	21
20	102	5	6,389	70	9	79	11	10	21
22	106	5	9,186	67	7	74	16	10	26
24	102	5	10,631	63	10	73	16	11	27
Average	—	—	5,484	66	11	77	12	11	23
				DRY					
12	83	5	1,196	55	23	78	4	18	22
14	94	5	1,847	63	12	75	10	15	25
16	96	6	2,227	64	13	77	10	13	23
18	98	6	2,847	68	9	77	12	11	23
20	102	5	3,467	68	8	78	11	11	22
22	106	5	5,109	65	7	72	17	11	28
24	102	5	5,792	62	10	72	16	12	28
Average	—	—	3,026	65	10	75	13	12	25

[1]Saw log to 8-inch d.i.b. or saw-log merchantable top.
[2]Pulpwood in stem from saw-log top to 4-inch d.i.b. top.
[3]Main stem to 4-inch d.i.b. top.

Table 5.—Average green and dry weights of bark in the total tree and distribution of bark in main stem and branches in northern red oak sawtimber trees

D.b.h. class (inches)	Average total height	Sample trees	Total-tree bark weight	Proportion of bark in —					
				Main stem			Branches (inches d.o.b.)		
				Saw-log[1]	Pulp-wood[2]	Total stem[3]	≥ 4 inches	< 4 inches	All crown
	Feet	*Number*	*Pounds*	..... *Percent*					
				GREEN					
12	83	5	402	45	19	64	5	31	36
14	94	5	586	51	11	62	10	28	38
16	96	6	656	51	12	63	13	24	37
18	98	6	841	55	9	64	14	22	36
20	102	5	1,047	56	8	64	15	21	36
22	106	5	1,719	52	6	58	21	21	42
24	102	5	1,904	47	9	56	21	23	44
Average	—	—	956	52	9	61	16	23	39
				DRY					
12	83	5	244	46	21	67	5	28	33
14	94	5	369	51	11	67	11	27	38
16	96	6	406	51	12	63	13	24	37
18	98	6	526	55	9	64	14	22	36
20	102	5	646	56	9	65	15	20	35
22	106	5	1,112	52	6	58	21	21	42
24	102	5	1,240	49	8	57	22	21	43
Average	—	—	605	52	9	61	17	22	39

[1]Saw log to 8-inch d.i.b. or saw-log merchantable top.
[2]Pulpwood in stem from saw-log top to 4-inch d.i.b. top.
[3]Main stem to 4-inch d.i.b. top.

in 6-inch trees to 88 percent in 24-inch trees, while the proportion in bark decreased from 15 percent in 6-inch trees to 12 percent in 24-inch trees. On the average, 88 percent of the stem green weight was wood and 12 percent was bark.

Crown Components

When the crown was analyzed separately, the proportion of its green weight in wood averaged 77 percent and the proportion in bark averaged 23 percent on a green basis. Comparable figures on a dry basis were 78 and 24 percent, respectively.

On the average, 6 percent of the weight of wood in pulpwood trees was in topwood, 5 percent in branches ≥ 2.0 inches d.o.b., and 10 percent was in branches < 2.0 inches d.o.b. (table 2). The average sawtimber tree had 12 percent of its wood in crown material ≥ 4.0 inches d.o.b. and 11 percent in branches < 4.0 inches d.o.b. (table 4).

Physical Properties

Wood and bark specific gravity, moisture content, and green weight per cubic foot for the total tree and its components are presented in table 6. Wood specific gravity and moisture content did not vary significantly with tree size. Wood specific gravity averaged 0.581 for the total tree and 0.574 for the stem—slightly higher than the 0.56 reported by the Forest Products Laboratory (1974) for northern red oak stem wood. Pulpwood had the highest wood specific gravity, averaging 0.608, and saw-log wood the lowest, averaging 0.568. Wood moisture content ranged from 69 percent in the branches to 85 percent in saw logs and averaged 80 percent for the total tree. Green weight of wood per cubic foot averaged 65 pounds in the main stem and total tree.

Specific gravity of bark was lowest in branches (0.589) and highest in the pulpwood sec-

Table 6.—Average wood and bark specific gravity, moisture content, and green weight per cubic foot for northern red oak trees and tree components

Tree component	Average and standard deviation		
	Specific gravity	Moisture content	Green weight per cubic foot
		Percent	*Pounds*
	WOOD		
Total tree	0.581 ± 0.020	80 ± 4.9	65 ± 1.5
Stem (butt to 4-inch d.i.b. top)	.574 ± .021	83 ± 5.4	65 ± 1.7
Saw log (butt to 8-inch d.i.b. top)	.568 ± .022	85 ± 5.8	66 ± 1.5
Pulpwood (8- to 4-inch d.i.b. top)	.608 ± .026	72 ± 4.7	65 ± 1.9
Branches	.605 ± .024	69 ± 4.0	64 ± 1.9
	BARK		
Total tree	0.616 ± .028	63 ± 5.8	62 ± 2.0
Stem (butt to 4-inch d.i.b. top)	.631 ± .032	61 ± 6.1	63 ± 2.3
Saw log (butt to 8-inch d.i.b. top)	.634 ± .038	58 ± 6.0	63 ± 2.5
Pulpwood (8- to 4-inch d.i.b. top)	.658 ± .038	55 ± 4.8	64 ± 2.2
Branches	.589 ± .046	66 ± 9.0	61 ± 2.6

tion of the main stem (0.658). Total-tree bark specific gravity was higher than wood specific gravity and averaged 0.616. Bark moisture content averaged 63 percent for the total tree, lower than the corresponding value for wood. Bark moisture content was the highest in branches (66 percent) and lowest in pulpwood (55 percent). Green bark weight per cubic foot ranged from 61 pounds in branches to 64 pounds in pulpwood and averaged 62 pounds in the total tree.

The weight of wood and bark per unit volume of wood is a useful factor for estimating the volume of wood in a tree or its components when weight of wood and bark is known. The average green weight of wood and bark per cubic foot of wood was 77 pounds for the total tree and 75 pounds for the stem (table 7). Branch green weight of wood and bark per cubic foot of wood averaged 83 pounds.

Green weight per cubic foot of wood and bark combined averaged 65 pounds for the total tree and the stem and 63 pounds for branches (table 7).

PREDICTION EQUATIONS

A series of equations was developed to predict weights and volumes of total trees and their components. Since tree height is measured to different top limits by various organizations, equations were developed using D^2 alone and in combination with Th, H4, and Mh as independent variables. When Th and H4 were used with D^2, the one-variable equation (2) and two-variable equation (3) predicted total-tree and component weights and volumes equally well. The use of height as a separate variable did not improve the coefficient of determination or reduce the standard error. Thus, the single variable equation was used to predict tree weight and volume when using D^2, D^2Th, and D^2H4 as the independent variable. When D^2 and Mh were used as separate variables in equation (3), the coefficient of determination (R^2) increased 15 to 20 percent and the standard error was reduced. Thus, the two-variable equation was used when D^2 and Mh were the independent variables.

All independent variable combinations were good predictors of weights and volumes, but equations using D^2Th were the best predictors of total-tree weights and volumes. Equations using D^2 + Mh were the best estimators of saw-log merchantable stem weight and volume, while equations using D^2H4 were the best predictors of stem weight and volume to a 4-inch top. When average tree heights and stem taper are similar to those of our sample trees, the equations using d.b.h. alone will result in good estimates of tree weight and volume. However, when average tree heights by d.b.h. classes are different, the equations that include a height variable should be ap-

Table 7.—Average green weight of wood and bark per cubic foot of wood and average weight of wood and bark per cubic foot of wood and bark for northern red oak trees and tree components

Tree component	Average and standard deviation	
	Green weight of wood and bark per cubic foot of wood	Green weight of wood and bark per cubic foot of wood and bark
	Pounds	
Total tree	77 ± 1.9	65 ± 1.4
Stem (butt to 4-in. d.i.b. top)	75 ± 1.9	65 ± 1.5
Saw log (butt to 8-in. d.i.b. top)	75 ± 1.8	65 ± 1.5
Pulpwood (8- to 4-in. d.i.b. top)	78 ± 3.2	65 ± 1.6
Branches	83 ± 3.2	63 ± 1.7

plied directly or used to develop local weight-volume tables based on d.b.h. alone.

Appendix tables 8 and 9 present equations for predicting all weights and volumes measured for total trees and all their components using D^2Th. Appendix tables 10 and 11 present equations that use D^2, D^2H4, and $D^2 + Mh$ to predict the green weights of wood and bark and volume of wood for the most important tree components. The Appendix also describes a method for placing confidence limits about predictions made with the equations.

A complete list of equations based on D^2, D^2H4, and D^2Mh for predicting the green and dry weights and volume of wood and bark of all tree components listed in tables 8 and 9 is available from the authors at the Southeastern Forest Experiment Station, Forestry Sciences Laboratory, Athens, Georgia 30602. Also available are uncorrected sums, sums of squares, and their cross products for the independent and dependent variables listed in tables 8 and 9. These data make it possible to statistically compare and combine equations. They also allow for the addition of observations and for computation of error terms.

BIOMASS TABLES

Equations based on D^2Th from tables 8 and 9 were used to develop tables of biomass weight and volume. Tables 12–15 show predicted green weights of wood and bark and wood alone in the total tree, the saw-log stem to an 8-inch d.i.b. or saw-log merchantable top, the stem to a 4-inch d.i.b. top, and the crown. Tables 16–19 show predicted green volumes of wood and bark and wood alone in the total tree and its components. The predicted weight or volume of bark in a tree or component can be estimated by subtracting the value in the table for wood alone from the corresponding value in the table for wood and bark combined.

Similar-size trees may vary in weight and volume because of differences in crown size, stem taper, and weight per cubic foot. Therefore the equations and tables should be applied only to trees growing in natural, fully stocked stands which have stem taper rates and weights per cubic foot similar to the trees sampled.

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Appendix

COMPUTATION OF CONFIDENCE LIMITS

Tables 8, 9, 10, and 11 contain the standard errors of the estimate, the sample mean of x, and the corrected sums of squares for x for each equation in $\log_{10}$ form. These statistics can be used to calculate approximate confidence limits in pounds or cubic feet using a modification of Cox's formula (Land 1972) for estimating confidence limits for lognormal means:

$$Y_{U,L} = 10^{\log Y \pm Z \sqrt{S^2_{y\cdot x}\left[\frac{1}{n} + \frac{(x-\bar{x})^2}{\Sigma(x-\bar{x})^2}\right] + \frac{S^2_{y\cdot x}}{2(n+1)}}} \quad (8)$$

where:

$Y_{U,L}$ = upper and lower limits for Y,
Y = predicted weight or volume of component from equation (6),
Z = value from the standard normal table for appropriate confidence level,
$S_{y\cdot x}$ = standard error of estimate for prediction equation,
n = number of observations used to develop equation,
$\bar{x}$ = sample mean of log x — (from table of equations),
$\Sigma(x-\bar{x})^2$ = corrected sums of squares for log x — (from table of equations),
x = value of independent variable in $\log_{10}$ form.

Cox's method of approximation sufficiently estimates actual confidence limits when applied to samples with small variances as occur in the total tree and stem weight and volume of northern red oak data sets. Thus, equation (8) should be used to approximate confidence limits for the single-variable equations presented in this Paper.

Table 8.—Regression equations for estimating above-stump green and dry weights of the total tree and its components for northern red oak trees 6 to 24 inches d.b.h., using d.b.h. and total height as independent variables

Weight (Y)	Regression equation[a]	Coefficient of determination (R^2)	Standard error[b] ($S_{y \cdot x}$)[c]	Number trees sampled (N)
Total tree (excluding foliage):				
Green weight	$Y = 0.18579\ (D^2Th)^{1.00655}$	0.99	0.0396	71
Dry weight	$Y = 0.10987\ (D^2Th)^{1.00179}$	.99	.0441	71
All wood in tree:				
Green weight	$Y = 0.14803\ (D^2Th)^{1.01315}$	.99	.0396	71
Dry weight	$Y = 0.08959\ (D^2Th)^{1.00423}$	.99	.0442	71
All bark in tree:				
Green weight	$Y = 0.03980\ (D^2Th)^{0.96995}$	.98	.0558	71
Dry weight	$Y = 0.02040\ (D^2Th)^{0.98937}$	.98	.0606	71
Wood and bark in stem from stump to saw-log merchantable top (trees ≥ 11.0 inches d.b.h.):				
Green weight	$Y = 0.05116\ (D^2Th)^{1.08771}$	.95	.0546	35
Dry weight	$Y = 0.02929\ (D^2Th)^{1.08388}$	.95	.0590	35
Wood in stem from stump to saw-log merchantable top (trees ≥ 11.0 inches d.b.h.):				
Green weight	$Y = 0.04433\ (D^2Th)^{1.08928}$	.95	.0554	35
Dry weight	$Y = 0.02605\ (D^2Th)^{1.08093}$	.94	.0602	35
Bark in stem from stump to saw-log merchantable top (trees ≥ 11.0 inches d.b.h.):				
Green weight	$Y = 0.00653\ (D^2Th)^{1.08088}$	.92	.0705	35
Dry weight	$Y = 0.00319\ (D^2Th)^{1.10598}$	.92	.0716	35
Wood and bark in stem from stump to 8-inch d.i.b. top (trees ≥ 11.0 inches d.b.h.):				
Green weight	$Y = 0.06016\ (D^2Th)^{1.08101}$	.97	.0445	35
Dry weight	$Y = 0.03445\ (D^2Th)^{1.07718}$	.96	.0496	35
Wood in stem from stump to 8-inch d.i.b top (trees ≥ 11.0 inches d.b.h.):				
Green weight	$Y = 0.05212\ (D^2Th)^{1.08258}$	.97	.0448	35
Dry weight	$Y = 0.03063\ (D^2Th)^{1.07422}$	.96	.0502	35
Bark in stem from stump to 8-inch d.i.b. top (trees ≥ 11.0 inches d.b.h.):				
Green weight	$Y = 0.00769\ (D^2Th)^{1.07418}$	.93	.0673	35
Dry weight	$Y = 0.00376\ (D^2Th)^{1.09928}$	.93	.0683	35
Wood and bark in stem from stump to 4-inch d.i.b. top:				
Green weight	$Y = 0.13729\ (D^2Th)^{1.00877}$	.99	.0356	71
Dry weight	$Y = 0.08222\ (D^2Th)^{1.00092}$	.99	.0388	71
Wood in stem from stump to 4-inch d.i.b. top:				
Green weight	$Y = 0.11034\ (D^2Th)^{1.01741}$	.99	.0370	71
Dry weight	$Y = 0.06691\ (D^2Th)^{1.00637}$	.99	.0404	71
Bark in stem from stump to 4-inch d.i.b. top:				
Green weight	$Y = 0.03040\ (D^2Th)^{0.95031}$	.98	.0519	71
Dry weight	$Y = 0.01591\ (D^2Th)^{0.96871}$	.98	.0548	71

Continued

Table 8.—Regression equations for estimating above-stump green and dry weights of the total tree and its components for northern red oak trees 6 to 24 inches d.b.h., using d.b.h. and total height as independent variables—Continued

Weight (Y)	Regression equation[a]	Coefficient of determination (R^2)	Standard error[b] ($S_{y \cdot x}$)[c]	Number trees sampled (N)
Wood and bark in crown (all branches and topwood < 4-inch d.i.b.):				
Green weight	$Y = 0.05004\ (D^2Th)^{0.99476}$	.92	.1249	71
Dry weight	$Y = 0.02858\ (D^2Th)^{0.99901}$	.92	.1259	71
Wood in crown (all branches and topwood < 4 inches d.i.b.):				
Green weight	$Y = 0.03901\ (D^2Th)^{0.99387}$	.92	.1290	71
Dry weight	$Y = 0.02337\ (D^2Th)^{0.99256}$	.92	.1277	71
Bark in crown (all branches and topwood < 4 inches d.i.b.):				
Green weight	$Y = 0.01107\ (D^2Th)^{0.99723}$	.93	.1186	71
Dry weight	$Y = 0.00542\ (D^2Th)^{1.01942}$	.93	.1235	71
Wood and bark in crown ≥ 4.0 inches d.o.b. (trees ≥ 11.0 inches d.b.h.):				
Green weight	$Y = 0.0000010\ (D^2Th)^{1.96022}$	.77	.2418	35
Dry weight	$Y = 0.0000007\ (D^2Th)^{1.94752}$	.77	.2420	35
Wood in crown ≥ 4.0 inches d.o.b. (trees ≥ 11.0 inches d.b.h.):				
Green weight	$Y = 0.00000086\ (D^2Th)^{1.95391}$	.76	.2475	35
Dry weight	$Y = 0.00000066\ (D^2Th)^{1.92791}$	.77	.2468	35
Bark in crown ≥ 4.0 inches d.o.b. (trees ≥ 11.0 inches d.b.h.):				
Green weight	$Y = 0.00000014\ (D^2Th)^{1.98740}$	.80	.2228	35
Dry weight	$Y = 0.00000006\ (D^2Th)^{2.02410}$	.80	.2288	35

[a] $Y = b_0 (D^2Th)^{b_1}$

where:

Y = component weight in pounds,
D = d.b.h. in inches,
Th = total height of tree in feet,
b_0, b_1 = regression coefficients.

[b] Standard error in $\log_{10}$ form.

[c] Additional statistics for computation of confidence intervals:

$\Sigma (x-\bar{x})^2 = 13.3864$ and $\bar{x} = 4.0718$ for equations based on 71 trees and
$\Sigma (x-\bar{x})^2 = 1.6835$ and $\bar{x} = 4.4538$ for equations based on 35 trees.

Table 9.—Regression equations for estimating above-stump green cubic-foot volume of the total tree and its components for northern red oak trees 6 to 24 inches d.b.h., using d.b.h. and total height as independent variables

Cubic-foot volume (Y)	Regression equation[a]	Coefficient of determination (R^2)	Standard error[b] ($S_{y \cdot x}$)[c]	Number trees sampled (N)
Total tree (excluding foliage):				
Wood	$Y = 0.002439\ (D^2Th)^{1.00568}$	0.99	0.0382	71
Bark	$Y = 0.000633\ (D^2Th)^{0.97091}$	.98	.0571	71
Wood & bark	$Y = 0.003052\ (D^2Th)^{1.00014}$	.99	.0390	71
Stem from stump to saw-log merchantable top (trees ≥ 11.0 inches d.b.h.):				
Wood	$Y = 0.000633\ (D^2Th)^{1.09537}$	.95	.0546	35
Bark	$Y = 0.000119\ (D^2Th)^{1.06819}$	.93	.0676	35
Wood & bark	$Y = 0.000753\ (D^2Th)^{1.09162}$	.95	.0537	35
Stem from stump to 8-inch d.i.b. top (trees ≥ 11.0 inches d.b.h.):				
Wood	$Y = 0.000745\ (D^2Th)^{1.08867}$	.97	.0451	35
Bark	$Y = 0.000140\ (D^2Th)^{1.06148}$	.93	.0650	35
Wood & bark	$Y = 0.000885\ (D^2Th)^{1.08492}$	.97	.0449	35
Stem from stump to 4-inch d.i.b. top:				
Wood	$Y = 0.001763\ (D^2Th)^{1.01258}$	.99	.0347	71
Bark	$Y = 0.000460\ (D^2Th)^{0.95492}$	.99	.0517	71
Wood & bark	$Y = 0.002183\ (D^2Th)^{1.00496}$	.99	.0339	71
Crown material (all branches and top-wood < 4 inches d.i.b. excluding foliage):				
Wood	$Y = 0.000697\ (D^2Th)^{0.97993}$	.92	.1295	71
Bark	$Y = 0.000188\ (D^2Th)^{0.99205}$	.93	.1200	71
Wood & bark	$Y = 0.000889\ (D^2Th)^{0.98263}$	.92	.1254	71
Crown material ≥ 4.0 inches d.o.b. (trees ≥ 11.0 inches d.b.h.):				
Wood	$Y = 0.0000000011\ (D^2Th)^{1.96775}$	.76	.2490	35
Bark	$Y = 0.000000002\ (D^2Th)^{1.98052}$	.80	.2239	35
Wood & bark	$Y = 0.000000013\ (D^2Th)^{1.96991}$	.77	.2434	35

[a] $Y = b_0\ (D^2Th)^{b_1}$

where:

Y = component volume in cubic feet,
D = d.b.h. in inches,
Th = total height of tree in feet,
b_0, b_1 = regression coefficients.

[b] Standard error in $\log_{10}$ form.

[c] Additional statistics for computation of confidence intervals:
$\Sigma(x-\bar{x})^2 = 13.3864$ and $\bar{x} = 4.0718$ for equations based on 71 trees and
$\Sigma(x-\bar{x})^2 = 1.6835$ and $\bar{x} = 4.4538$ for equations based on 35 trees.

Table 10.—Regression equations for estimating above-stump wood and bark green weights for northern red oak trees 6 to 24 inches d.b.h. and tree components using d.b.h., d.b.h. and height to 4-inch top, and d.b.h. and saw-log merchantable height as independent variables

Weight (Y)	Regression equation[a]	Coefficient of determination (R^2)	Standard error[b] ($S_{y \cdot x}$)	Sample mean of x[b] ($\bar{x}$)	Corrected sums of squares for x[b] $\Sigma(x-\bar{x})^2$	Number trees sampled (N)
Wood and bark in total tree, above stump						
	$Y = 5.44299\ (D^2)^{1.22075}$	0.99	0.0449	2.1559	9.0800	71
	$Y = 0.88448\ (D^2H4)^{0.87511}$	.99	.0506	3.9096	17.6201	71
	$Y = 5.97051\ (D^2)^{1.10049}(Mh)^{0.15495}$	.96	.0470	—	—	35
Wood and bark in stem stump to saw-log merchantable top						
	$Y = 2.78219\ (D^2)^{1.25916}$	.93	.0675	2.4697	1.2235	35
	$Y = 0.16293\ (D^2H4)^{0.99965}$	.96	.0524	4.3428	2.0010	35
	$Y = 0.76536\ (D^2)^{0.99153}(Mh)^{0.72285}$	.98	.0324	—	—	35
Wood and bark in stem from stump to 4-inch d.i.b. top						
	$Y = 4.11043\ (D^2)^{1.22077}$	.99	.0508	2.1559	9.0800	71
	$Y = 0.64173\ (D^2H4)^{0.87933}$	.99	.0352	3.9096	17.6201	71
	$Y = 4.02330\ (D^2)^{0.97341}(Mh)^{0.36878}$	.97	.0402	—	—	35
Wood and bark in crown (all branches and topwood ≥ 4-inches d.i.b.)						
	$Y = 1.34314\ (D^2)^{1.21542}$	.94	.1148	2.1559	9.0800	71
	$Y = 0.24995\ (D^2H4)^{0.85787}$	.90	.1409	3.9096	17.6201	71
	$Y = 2.00506\ (D^2)^{1.52753}(Mh)^{-0.55400}$	.82	.1231	—	—	35

[a] $Y = a(D^2)^b$ or $Y = a(D^2H4)^b$ or $Y = a(D^2)^{b_1}(Mh)^{b_2}$

where:

Y = component weight in pounds,
D = d.b.h. in inches,
H4 = tree height to 4-inch d.i.b. top in feet,
Mh = saw-log merchantable height in feet,
a, b_1, b_2 = regression coefficients.

[b] $\log_{10}$ form.

Table 11.—Regression equations for estimating above-stump wood volume for northern red oak trees 6 to 24 inches d.b.h. and tree components using d.b.h., d.b.h. and height to a 4-inch top, and d.b.h. and saw-log merchantable height as independent variables

Cubic-foot volume (Y)	Regression equation[a]	Coefficient of determination (R^2)	Standard error[b] ($S_{y \cdot x}$)	Sample mean of x^b ($\bar{x}$)	Corrected sums of squares for x^b $\Sigma(x-\bar{x})^2$	Number trees sampled (N)
Wood in total tree, above stump						
	$Y = 0.07138\ (D^2)^{1.21940}$	0.99	0.0447	2.1559	9.0800	71
	$Y = 0.01158\ (D^2H4)^{0.87451}$	.99	.0488	3.9096	17.6201	71
	$Y = 0.07462\ (D^2)^{1.09146}(Mh)^{0.17888}$	.96	.0470	—	—	35
Wood in stem from stump to saw-log merchantable top						
	$Y = 0.03550\ (D^2)^{1.26778}$	.93	.0679	2.4697	1.2235	35
	$Y = 0.00203\ (D^2H4)^{1.00689}$	.96	.0522	4.3428	2.0010	35
	$Y = 0.0982\ (D^2)^{1.00120}(Mh)^{0.72000}$	.98	.0336	—	—	35
Wood in stem from stump to 4-inch d.i.b. top						
	$Y = 0.05348\ (D^2)^{1.22531}$	.99	.0505	2.1559	9.0800	71
	$Y = 0.00828\ (D^2H4)^{0.88272}$	.99	.0338	3.9096	17.6201	71
	$Y = 0.05099\ (D^2)^{0.98216}(Mh)^{0.36979}$	.96	.0415	—	—	35
Wood in crown (all branches and topwood < 4 inches d.i.b.)						
	$Y = 0.01781\ (D^2)^{1.19740}$	.93	.1200	2.1559	9.0800	71
	$Y = 0.00341\ (D^2H4)^{0.84488}$	.90	.1442	3.9096	17.6201	71
	$Y = 0.02450\ (D^2)^{1.51110}(Mh)^{-0.53521}$	.80	.1299	—	—	35

[a] $Y = a(D^2)^b$ or $Y = a(D^2H4)^b$ or $Y = a(D^2)^{b_1}(Mh)^{b_2}$

where:

Y = component volume in cubic feet,
D = d.b.h. in inches,
H4 = tree height to 4-inch d.i.b. top in feet,
Mh = saw-log merchantable height in feet,
a, b_1, b_2 = regression coefficients.

[b] $\log_{10}$ form.

Table 12.—Predicted green weight of total-tree wood and bark, above stump, for northern red oak trees[1]

D.b.h. (inches)	Total-tree height[2] (feet)							
	50	60	70	80	90	100	110	120
	Pounds							
	WOOD AND BARK[3]							
5	243	292	341	391				
6	351	422	493	564				
7	479	576	672	769	866			
8	627	753	879	1,006	1,133			
9	795	955	1,115	1,275	1,436	1,596		
10	982	1,180	1,378	1,576	1,775	1,973		
11	1,190	1,430	1,670	1,910	2,150	2,391	2,632	
12	1,418	1,703	1,989	2,275	2,562	2,849	3,135	
13		2,001	2,337	2,673	3,010	3,347	3,684	4,021
14		2,323	2,713	3,103	3,494	3,885	4,276	4,668
15		2,669	3,117	3,566	4,015	4.464	4,913	5,363
16			3,550	4,061	4,572	5,083	5,595	6,107
17			4,011	4,588	5,165	5,743	6,321	6,900
18			4,500	5,147	5,795	6,443	7,092	7,741
19			5,017	5,739	6,461	7,184	7,908	8,631
20			5,563	6,363	7,164	7,966	8,768	9,570
21			6,137	7,020	7,904	8,788	9,673	10,558
22			6,740	7,709	8,680	9,651	10,622	11,595
23			7,371	8,431	9,492	10,554	11,617	12,680
24			8,030	9,185	10,341	11,498	12,656	13,814
25			8,718	9,972	11,227	12,483	13,740	14,997
	WOOD[4]							
5	203	244	286	327				
6	294	354	414	473				
7	402	483	565	647	729			
8	527	634	741	848	955			
9	669	804	940	1,077	1,213	1,350		
10	828	996	1,164	1,333	1,502	1,671		
11	1,004	1,208	1,412	1,617	1,822	2,027	2,232	
12	1,198	1,441	1,684	1,928	2,173	2,418	2,663	
13		1,695	1,981	2,268	2,555	2,843	3,132	3,420
14		1,969	2,302	2,635	2,970	3,304	3,639	3,974
15		2,265	2,647	3,031	3,415	3,800	4,185	4,571
16			3,017	3,454	3,892	4,331	4,770	5,209
17			3,412	3,906	4,401	4,897	5,393	5,890
18			3,831	4,386	4,941	5,498	6,055	6,613
19			4,274	4,893	5,513	6,135	6,756	7,379
20			4,742	5,429	6,117	6,806	7,497	8,187
21			5,235	5,993	6,753	7,514	8,276	9,038
22			5,753	6,586	7,421	8,257	9,094	9,932
23			6,295	7,207	8,120	9,035	9,951	10,868
24			6,862	7,856	8,851	9,848	10,847	11,847
25			7,453	8,533	9,615	10,698	11,782	12,868

[1]Blocked-in area indicates range of data.
[2]Includes 1-foot stump allowance.
[3]$Y = 0.18579\ (D^2Th)^{1.00655}$.
[4]$Y = 0.14803\ (D^2Th)^{1.01315}$.

Table 13.—Predicted green weight of wood and bark in saw-log stem to 8-inch d.i.b. or saw-log merchantable top for northern red oak trees[1]

D.b.h. (inches)	Total-tree height[2] (feet)						
	60	70	80	90	100	110	120
	Pounds						
	WOOD AND BARK[3]						
11	810	958	1,108	1,259	1,412	1,566	
12	979	1,158	1,338	1,521	1,706	1,893	
13	1,165	1,378	1,593	1,811	2,031	2,253	2,476
14	1,369	1,619	1,872	2,128	2,386	2,647	2,909
15	1,590	1,881	2,175	2,472	2,772	3,075	3,380
16		2,164	2,503	2,845	3,190	3,539	3,890
17		2,469	2,855	3,246	3,640	4,038	4,438
18		2,796	3,234	3,676	4,122	4,572	5,026
19		3,145	3,637	4,134	4,636	5,143	5,653
20		3,517	4,067	4,622	5,184	5,750	6,321
21		3,911	4,522	5,140	5,764	6,394	7,028
22		4,327	5,003	5,687	6,378	7,075	7,777
23		4,766	5,511	6,265	7,026	7,793	8,567
24		5,229	6,046	6,873	7,707	8,549	9,398
25		5,714	6,608	7,511	8,423	9,343	10,270
	WOOD[4]						
11	712	842	974	1,107	1,242	1,377	
12	860	1,018	1,177	1,338	1,501	1,665	
13	1,024	1,211	1,401	1,593	1,787	1,982	2,179
14	1.204	1,424	1,647	1,872	2,100	2,329	2,561
15	1,399	1,655	1,914	2,176	2,440	2,707	2,976
16		1,904	2,203	2,504	2,809	3,116	3,426
17		2,173	2,514	2,858	3,205	3,556	3,909
18		2,462	2,847	3,237	3,630	4,027	4,428
19		2,769	3,203	3,641	4,084	4,531	4,981
20		3,097	3,581	4,072	4,567	5,067	5,570
21		3,444	3,983	4,528	5,079	5,635	6,195
22		3,811	4,408	5,011	5,621	6,236	6,856
23		4,199	4,856	5,521	6,192	6,870	7,553
24		4,607	5,328	6,057	6,794	7,537	8,287
25		5,035	5,824	6,621	7,426	8,238	9,057

[1]Blocked-in area indicates range of data.
[2]Includes 1-foot stump allowance.
[3]$Y = 0.05116(D^2Th)^{1.08771}$.
[4]$Y = 0.04433(D^2Th)^{1.08928}$.

Table 14.—Predicted green weight of wood and bark in stem to 4-inch d.i.b. top for northern red oak trees[1]

D.b.h. (inches)	Total-tree height[2] (feet)							
	50	60	70	80	90	100	110	120
	Pounds							
	WOOD AND BARK[3]							
5	183	220	257	294				
6	264	317	371	424				
7	360	433	506	579	652			
8	472	567	662	758	853			
9	598	719	840	961	1,082	1,203		
10	740	889	1,039	1,188	1,338	1,488		
11	897	1,078	1,259	1,440	1,622	1,804	1,986	
12	1,069	1,284	1,500	1,717	1,933	2,150	2,367	
13		1,509	1,763	2,018	2,272	2,527	2,782	3,037
14		1,753	2,048	2,343	2,639	2,935	3,231	3,527
15		2,015	2,354	2,693	3,033	3,373	3,713	4,054
16			2,681	3,067	3,454	3,842	4,230	4,618
17			3,030	3,467	3,904	4,342	4,780	5,218
18			3,400	3,890	4,381	4,872	5,364	5,856
19			3,792	4,339	4,886	5,434	5,982	6,531
20			4,205	4,812	5,419	6,026	6,635	7,243
21			4,640	5,309	5,979	6,650	7,321	7,993
22			5,097	5,832	6,568	7,304	8,041	8,779
23			5,575	6,379	7,184	7,989	8,796	9,603
24			6,075	6,951	7,828	8,706	9,584	10,464
25			6,597	7,548	8,500	9,453	10,407	11,362
	WOOD[4]							
5	156	188	220	252				
6	226	272	319	365				
7	310	373	436	500	563			
8	406	489	572	656	739			
9	516	622	727	833	939	1,045		
10	640	770	901	1,032	1,164	1,295		
11	777	935	1,094	1,253	1,413	1,573	1,733	
12	927	1,116	1,306	1,496	1,686	1,877	2,068	
13		1,314	1,537	1,760	1,985	2,209	2,434	2,659
14		1,528	1,787	2,047	2,308	2,569	2,830	3,092
15		1,758	2,056	2,356	2,655	2,956	3,257	3,558
16			2,345	2,686	3,028	3,371	3,714	4,058
17			2,653	3,039	3,426	3,813	4,202	4,590
18			2,980	3,414	3,848	4,284	4,720	5,157
19			3,326	3,811	4,296	4,782	5,269	5,756
20			3,692	4,230	4,768	5,308	5,848	6,390
21			4,078	4,671	5,266	5,862	6,459	7,056
22			4,483	5,135	5,789	6,444	7,100	7,757
23			4,907	5,621	6,337	7,054	7,772	8,491
24			5,351	6,130	6,910	7,692	8,475	9,260
25			5,814	6,661	7,508	8,358	9,209	10,062

[1]Blocked-in area indicates range of data.
[2]Includes 1-foot stump allowance.
[3]$Y = 0.13724(D^2Th)^{1.00877}$.
[4]$Y = 0.11034(D^2Th)^{1.01741}$.

Table 15.—Predicted green weight of wood and bark in crown for northern red oak trees[1]

D.b.h. (inches)	Total-tree height[2] (feet)							
	50	60	70	80	90	100	110	120
	Pounds							
	WOOD AND BARK[3]							
5	60	72	96					
6	87	104	121	138				
7	118	141	164	188	211			
8	153	184	215	245	275			
9	194	233	271	310	348	387		
10	239	287	334	382	429	477		
11	289	347	404	462	519	576	634	
12	344	412	481	549	617	685	753	
13		483	564	644	724	804	884	963
14		560	653	746	839	931	1,024	1,116
15		643	749	856	962	1,068	1,175	1,281
16			852	973	1,094	1,215	1,335	1,456
17			961	1,098	1,234	1,370	1,507	1,643
18			1,077	1,230	1,383	1,535	1,688	1,841
19			1,199	1,369	1,540	1,710	1,880	2,050
20			1,328	1,517	1,705	1,893	2,082	2,270
21			1,463	1,671	1,879	2,087	3,294	2,501
22			1,605	1,833	2,061	2,289	2,516	2,744
23			1,754	2,003	2,252	2,500	2,749	2,998
24			1,909	2,180	2,451	2,721	2.992	3,263
25			2,070	2,364	2,658	2,952	3,245	3,539
	WOOD[4]							
5	47	56	65	74				
6	67	80	94	107				
7	91	109	127	145	163			
8	119	142	166	190	213			
9	150	180	210	240	269	299		
10	185	222	259	295	332	369		
11	244	268	313	357	401	446	490	
12	266	319	372	424	477	530	582	
13		374	436	498	559	621	683	744
14		433	505	577	648	720	791	863
15		497	579	661	743	825	907	989
16			658	752	845	938	1,032	1,125
17			743	848	953	1,059	1,164	1,269
18			832	950	1,068	1,186	1,304	1,422
19			926	1,058	1,189	1,321	1,452	1,583
20			1,026	1,171	1,317	1,462	1,608	1,753
21			1,130	1,291	1,451	1,611	1,771	1,931
22			1,240	1,416	1,592	1,767	1,943	2,118
23			1,354	1,547	1,739	1,931	2,122	2,314
24			1,474	1,683	1,892	2,101	2,310	2,518
25			1,598	1,825	2,052	2,279	2,505	2,731

[1]Blocked-in area indicates range of data.
[2]Includues 1-foot stump allowance.
[3]$Y = 0.05004\ (D^2Th)^{0.99476}$.
[4]$Y = 0.03901\ (D^2Th)^{0.99387}$.

Table 16.—Predicted volume of above-stump total-tree wood and bark for northern red oak trees[1]

D.b.h. (inches)	Total-tree height[2] (feet)							
	50	60	70	80	90	100	110	120
	Cubic feet							
	WOOD AND BARK[3]							
5	3.8	4.6	5.3	6.1				
6	5.5	6.6	7.7	8.8				
7	7.5	9.0	10.5	12.0	13.5			
8	9.8	11.7	13.7	15.6	17.6			
9	12.4	14.8	17.3	19.8	22.3	24.7		
10	15.3	18.3	21.4	24.4	27.5	30.5		
11	18.5	22.2	25.9	29.6	33.3	37.0	40.6	
12	22.0	26.4	30.8	35.2	39.6	44.0	48.4	
13		31.0	36.1	41.3	46.5	51.6	56.8	61.9
14		35.9	41.9	47.9	53.9	59.9	65.8	71.8
15		41.2	48.1	55.0	61.8	68.7	75.6	82.5
16			54.7	62.6	70.4	78.2	86.0	93.8
17			61.8	70.6	79.4	88.3	97.1	105.9
18			69.3	79.2	89.1	99.0	108.9	118.8
19			77.2	88.2	99.2	110.3	121.3	132.3
20			85.5	97.7	110.0	122.2	134.4	146.6
21			94.3	107.8	121.2	134.7	148.2	161.7
22			103.5	118.3	133.1	147.8	162.6	177.4
23			113.1	129.3	145.4	161.6	177.8	193.9
24			123.2	140.8	158.4	175.9	193.5	211.1
25			133.6	152.7	171.8	190.9	210.0	229.1
	WOOD[4]							
5	3.2	3.8	4.5	5.1				
6	4.6	5.5	6.4	7.3				
7	6.2	7.5	8.8	10.0	11.3			
8	8.2	9.8	11.5	13.1	14.8			
9	10.4	12.4	14.5	16.6	18.7	20.8		
10	12.8	15.4	18.0	20.5	23.1	25.7		
11	15.5	18.6	21.7	24.9	28.0	31.1	34.3	
12	18.5	22.2	25.9	29.6	33.4	37.1	40.8	
13		26.1	30.4	34.8	39.2	43.6	47.9	52.3
14		30.3	35.3	40.4	45.5	50.6	55.7	60.7
15		34.8	40.6	46.4	52.3	58.1	63.9	69.8
16			46.2	52.8	59.5	66.1	72.8	79.5
17			52.2	59.7	67.2	74.7	82.2	89.8
18			58.6	67.0	75.4	83.8	92.3	100.7
19			65.3	74.7	84.1	93.5	102.9	112.3
20			72.4	82.8	93.2	103.6	114.0	124.5
21			79.8	91.3	102.8	114.3	125.8	137.3
22			87.7	100.3	112.9	125.5	138.1	150.8
23			95.9	109.7	123.4	137.2	151.0	164.9
24			104.4	119.5	134.5	149.5	164.5	179.6
25			113.4	129.7	146.0	162.3	178.6	195.0

[1]Blocked-in area indicates range of data.
[2]Includes 1-foot stump allowance.
[3]$Y = 0.003050\ (D^2Th)^{1.00014}$.
[4]$Y = 0.002439\ (D^2Th)^{1.00568}$.

Table 17.—Predicted volume of wood and bark in saw-log stem to 8-inch d.i.b. or saw-log merchantable top for northern red oak trees[1]

D.b.h. (inches)	Total-tree height[2] (feet)						
	60	70	80	90	100	110	120
	Cubic feet						
	WOOD AND BARK[3]						
11	12.3	14.6	16.9	19.2	21.6	23.9	
12	14.9	17.7	20.4	23.2	26.1	28.9	
13	17.8	21.0	24.3	27.7	31.0	34.5	37.9
14	20.9	24.7	28.6	32.5	36.5	40.5	44.5
15	24.3	28.7	33.3	37.8	42.4	47.1	51.8
16		33.1	38.3	43.5	48.9	54.2	59.6
17		37.8	43.7	49.7	55.8	61.9	68.1
18		42.8	49.5	56.3	63.2	70.1	77.1
19		48.2	55.7	63.4	71.1	78.9	86.8
20		53.9	62.3	70.9	79.5	88.2	97.0
21		59.9	69.3	78.9	88.5	98.2	107.9
22		66.3	76.7	87.3	97.9	108.7	119.5
23		73.1	84.6	96.2	107.9	119.7	131.7
24		80.2	92.8	105.5	118.4	131.4	144.5
25		87.7	101.5	115.4	129.4	143.6	157.9
	WOOD[4]						
11	10.7	12.7	14.7	16.7	18.8	20.8	
12	13.0	15.4	17.8	20.2	22.7	25.2	27.7
13	15.5	18.3	21.2	24.1	27.1	30.0	33.1
14	18.2	21.5	24.9	28.4	31.8	35.3	38.9
15	21.2	25.1	29.0	33.0	37.0	41.1	45.2
16		28.9	33.4	38.0	42.7	47.4	52.1
17		33.0	38.2	43.4	48.7	54.1	59.5
18		37.4	43.2	49.2	55.2	61.3	67.4
19		42.1	48.7	55.4	62.2	69.0	75.9
20		47.1	54.5	62.0	69.6	77.2	84.9
21		52.4	60.6	69.0	77.4	85.9	94.5
22		58.0	67.1	76.4	85.7	95.1	104.7
23		63.9	74.0	84.2	94.5	104.9	115.4
24		70.2	81.2	92.4	103.7	115.1	126.6
25		76.7	88.8	101.1	113.4	125.9	138.5

[1]Blocked-in area indicates range of data.
[2]Includes 1-foot stump allowance.
[3]$Y = 0.000753\ (D^2Th)^{1.09162}$.
[4]$Y = 0.000633\ (D^2Th)^{1.09537}$.

Table 18.—Predicted volume of wood and bark in stem to 4-inch d.i.b. top for northern red oak trees[1]

D.b.h. (inches)	Total-tree height[2] (feet)							
	50	60	70	80	90	100	110	120
	Cubic feet							
	WOOD AND BARK[3]							
5	2.8	3.4	4.0	4.5				
6	4.1	4.9	5.7	6.5				
7	5.6	6.7	7.8	8.9	10.0			
8	7.3	8.7	10.2	11.7	13.1			
9	9.2	11.1	12.9	14.8	16.6	18.5		
10	11.4	13.7	16.0	18.3	20.6	22.9		
11	13.8	16.6	19.3	22.1	24.9	27.7	30.5	
12	16.4	19.7	23.0	26.3	29.7	33.0	36.3	
13		23.2	27.1	30.9	34.8	38.7	42.6	46.5
14		26.9	31.4	35.9	40.4	44.9	49.5	54.0
15		30.9	36.1	41.3	46.4	51.6	56.8	62.0
16			41.1	47.0	52.9	58.8	64.7	70.6
17			46.4	53.0	59.7	66.4	73.1	79.7
18			52.0	59.5	67.0	74.5	82.0	89.4
19			58.0	66.3	74.7	83.0	91.4	99.7
20			64.3	73.5	82.8	92.0	101.3	110.5
21			70.9	81.1	91.3	101.5	111.7	121.9
22			77.9	89.1	100.3	111.5	122.7	133.9
23			85.2	97.4	109.6	121.9	134.1	146.4
24			92.8	106.1	119.4	132.8	146.1	159.5
25			100.7	115.2	129.6	144.1	158.6	173.1
	WOOD[4]							
5	2.4	2.9	3.4	3.9				
6	3.5	4.2	4.9	5.6				
7	4.8	5.7	6.7	7.7	8.6			
8	6.2	7.5	8.8	10.1	11.3			
9	7.9	9.5	11.1	12.8	14.4	16.0		
10	9.8	11.8	13.8	15.8	17.8	19.8		
11	11.9	14.3	16.7	19.2	21.6	24.0	26.4	
12	14.2	17.1	20.0	22.8	25.7	28.6	31.5	
13		20.1	23.5	26.9	30.3	33.7	37.1	40.5
14		23.3	27.3	31.2	35.2	39.1	43.1	47.1
15		26.8	31.4	35.9	40.4	45.0	49.6	54.1
16			35.7	40.9	46.1	51.3	56.5	61.7
17			40.4	46.3	52.1	58.0	63.9	69.7
18			45.4	51.9	58.5	65.1	71.7	78.3
19			50.6	57.9	65.3	72.6	80.0	87.4
20			56.2	64.3	72.4	80.6	88.7	96.9
21			62.0	71.0	79.9	88.9	98.0	107.0
22			68.1	78.0	87.8	97.7	107.6	117.5
23			74.5	85.3	96.1	106.9	117.8	128.6
24			81.2	93.0	104.8	116.6	128.4	140.2
25			88.2	101.0	113.8	126.6	139.4	152.3

[1]Blocked-in area indicates range of data.
[2]Includes 1-foot stump allowance.
[3]$Y = 0.002183\ (D^2Th)^{1.00496}$.
[4]$Y = 0.001763\ (D^2Th)^{1.01258}$.

Table 19.—Predicted volume of wood and bark in crown for northern red oak trees[1]

D.b.h. (inches)	Total-tree height[2] (feet)							
	50	60	70	80	90	100	110	120
	Cubic feet							
	WOOD AND BARK[3]							
5	1.0	1.2	1.4	1.6				
6	1.4	1.7	2.0	2.2				
7	1.9	2.3	2.6	3.0	3.4			
8	2.5	3.0	3.4	3.9	4.4			
9	3.1	3.7	4.3	4.9	5.6	6.2		
10	3.8	4.6	5.3	6.1	6.8	7.6		
11	4.6	5.5	6.4	7.3	8.2	9.1	10.0	
12	5.5	6.6	7.6	8.7	9.8	10.8	11.9	
13		7.7	8.9	10.2	11.4	12.7	13.9	15.2
14		8.9	10.3	11.8	13.2	14.7	16.1	17.6
15		10.2	11.8	13.5	15.2	16.8	18.5	20.1
16			13.4	15.3	17.2	19.1	21.0	22.8
17			15.1	17.3	19.4	21.5	23.6	25.7
18			16.9	19.3	21.7	24.0	26.4	28.8
19			18.8	21.5	24.1	26.7	29.4	32.0
20			20.8	23.8	26.7	29.6	32.5	35.4
21			22.9	26.1	29.4	32.6	35.8	38.9
22			25.1	28.7	32.2	35.7	39.2	42.7
23			27.4	31.3	35.1	38.9	42.8	46.6
24			29.8	34.0	38.2	42.3	46.5	50.6
25			32.3	36.8	41.4	45.9	50.4	54.9
	WOOD[4]							
5	0.8	0.9	1.0	1.2				
6	1.1	1.3	1.5	1.7				
7	1.5	1.7	2.0	2.3	2.6			
8	1.9	2.3	2.6	3.0	3.4			
9	2.4	2.9	3.3	3.8	4.3	4.7		
10	2.9	3.5	4.1	4.7	5.2	5.8		
11	3.5	4.2	4.9	5.6	6.3	7.0	7.7	
12	4.2	5.0	5.8	6.7	7.5	8.3	9.1	
13		5.9	6.8	7.8	8.7	9.7	10.6	11.6
14		6.8	7.9	9.0	10.1	11.2	12.3	13.4
15		7.8	9.0	10.3	11.6	12.8	14.1	15.3
16			10.3	11.7	13.1	14.6	16.0	17.4
17			11.6	13.2	14.8	16.4	18.0	19.6
18			12.9	14.7	16.5	18.3	20.1	21.9
19			14.4	16.4	18.4	20.4	22.4	24.4
20			15.9	18.1	20.3	22.5	24.7	26.9
21			17.5	19.9	22.4	24.8	27.2	29.7
22			19.2	21.8	24.5	27.2	29.8	32.5
23			20.9	23.8	26.7	29.6	32.5	35.4
24			22.7	25.9	29.1	32.2	35.4	38.5
25			24.6	28.0	31.5	34.9	38.3	41.7

[1]Blocked-in area indicates range of data.
[2]Includes 1-foot stump allowance.
[3]$Y = 0.000889 (D^2Th)^{0.98263}$.
[4]$Y = 0.000697 (D^2Th)^{0.97993}$.

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Clark, Alexander, III, Douglas R. Phillips, and James G. Schroeder
1980. Predicted weights and volumes of northern red oak trees in western North Carolina. USDA For. Serv., Res. Pap. SE-209, 22 p. Southeast. For. Exp. Stn., Asheville, N.C.

Equations are presented for predicting green and dry weights and volume of the total tree, above stump, and its components using d.b.h. and total height, d.b.h. and height to a 4-inch top, d.b.h. and saw-log merchantable height, and d.b.h. alone. Tables developed from equations show weight and volume of the total tree and its components, by d.b.h. and total-height class.

KEYWORDS: *Quercus rubra* L., biomass, component proportions, equations, specific gravity, moisture content, weight per cubic foot.

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KEYWORDS: *Quercus rubra* L., biomass, component proportions, equations, specific gravity, moisture content, weight per cubic foot.

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